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Puricelli

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(54) **ROTOR ASSEMBLY FOR AN AIRCRAFT CAPABLE OF HOVERING AND EQUIPPED WITH AN IMPROVED CONSTRAINT ASSEMBLY**

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B64C 27/605 (2006.01)
B64C 27/32 (2006.01)

(52) **U.S. Cl.**
CPC ***B64C 27/605*** (2013.01); ***B64C 27/32*** (2013.01)

(58) **Field of Classification Search**
CPC B64C 27/12; B64C 27/605; B64C 27/625
See application file for complete search history.

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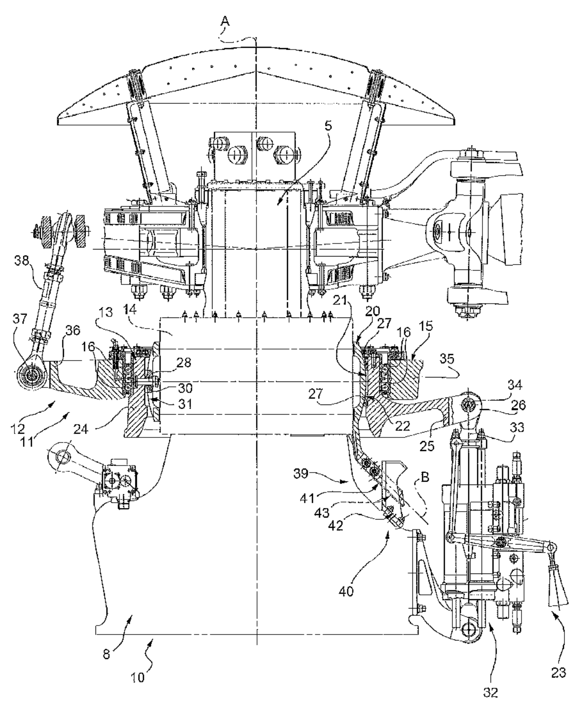
(57) **ABSTRACT**

A constraint assembly for an aircraft, having a first member; a second member mounted to translate along and rotate about its own axis; and connecting means for connecting the first and second member, to prevent rotation of the second member about the axis with respect to the first member; the connecting means having a retaining arm, which projects outwards from one of the first and second member, and extends at a distance of other than zero from the axis; and an antirotation bracket, which projects from the other of the first and second member, extends at a distance of other than zero from the axis, and defines a through opening engaged in sliding manner by the retaining arm.

8 Claims, 8 Drawing Sheets



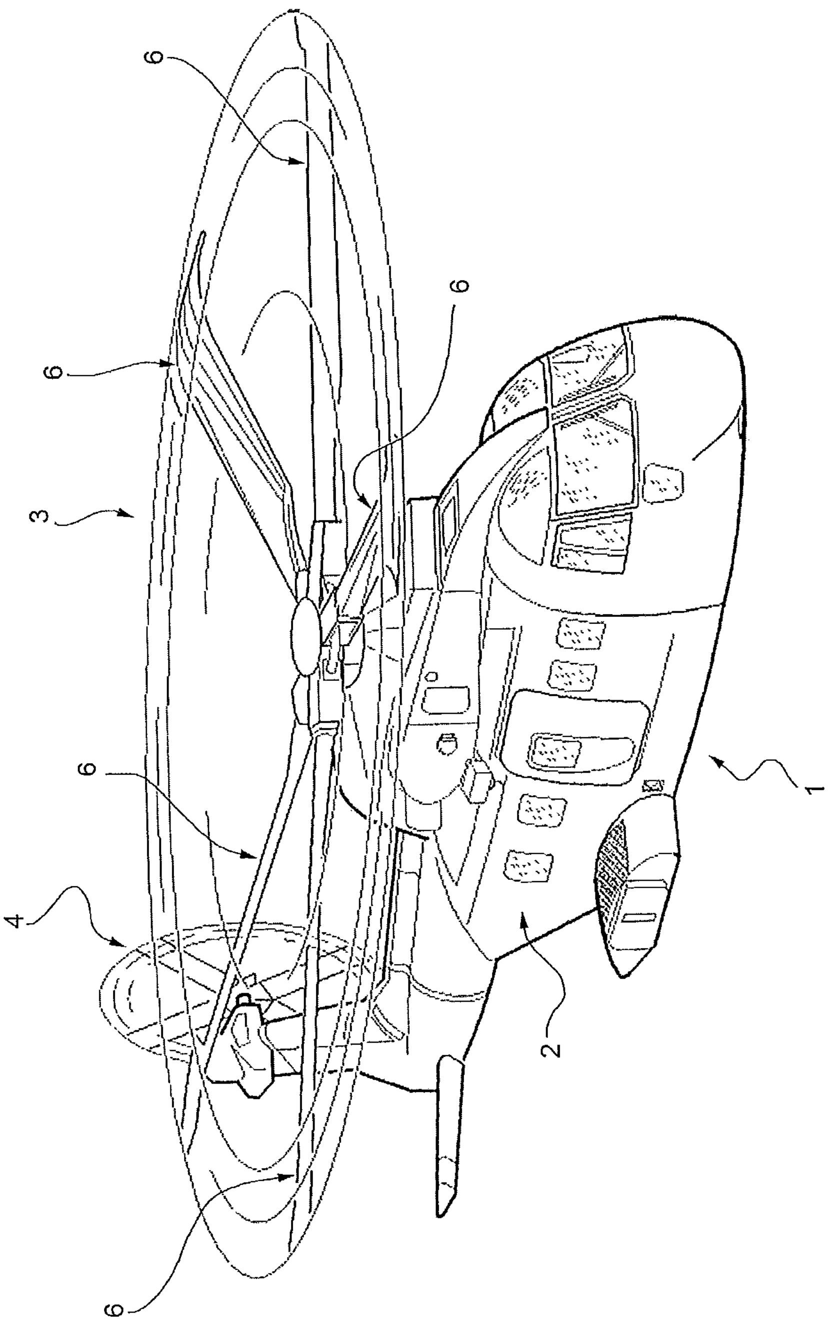


FIG. 1

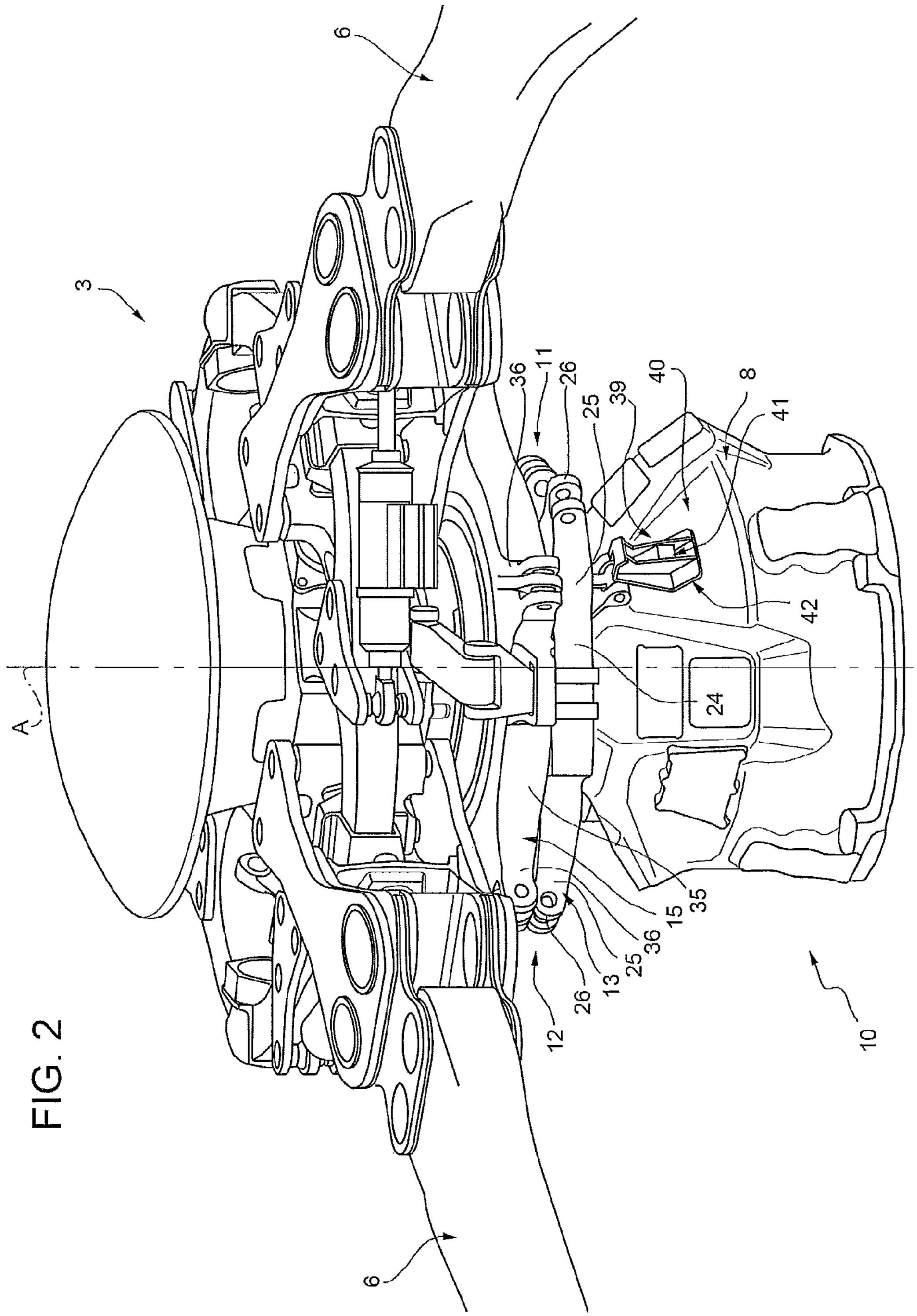


FIG. 2

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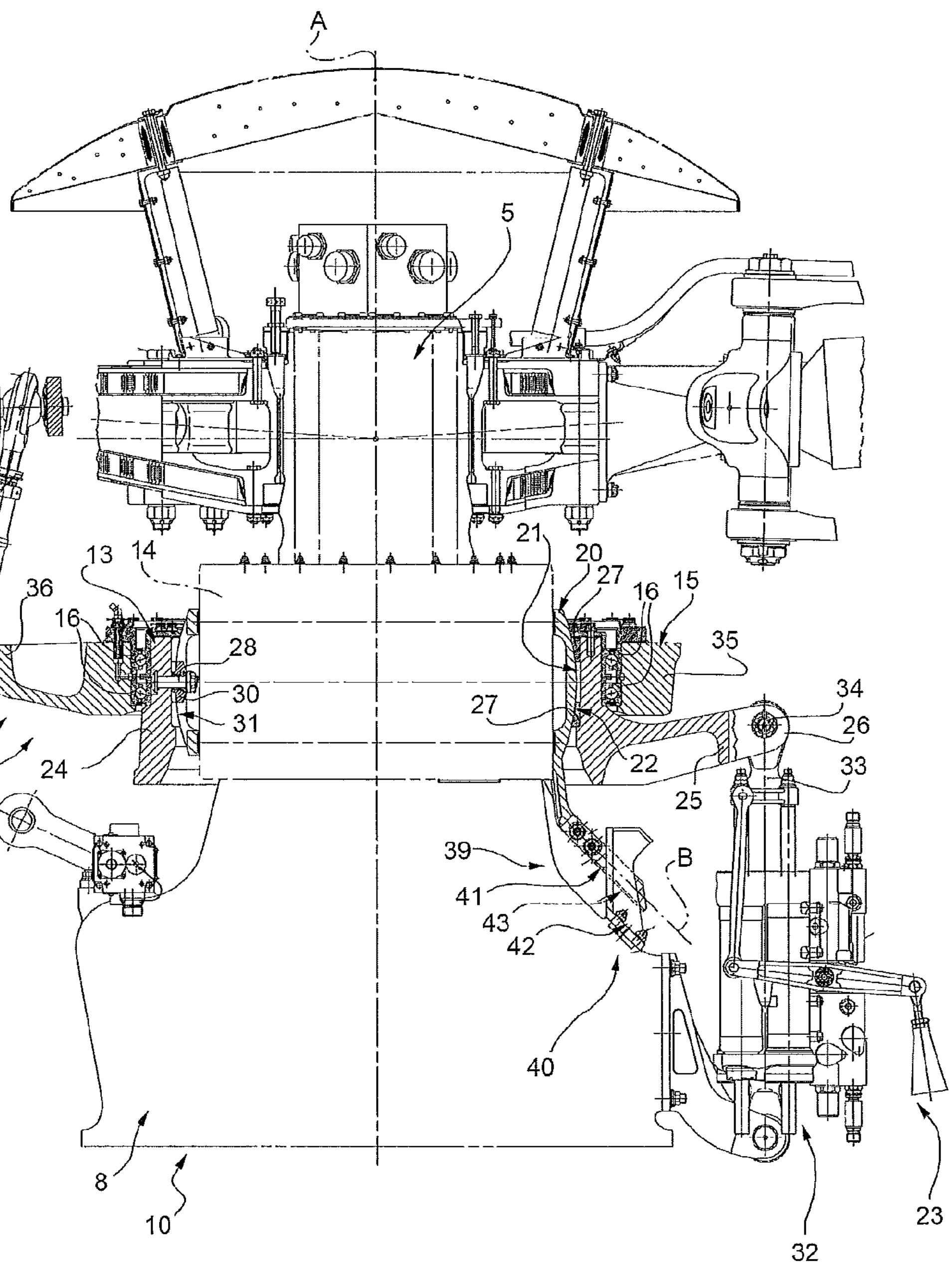
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FIG. 4

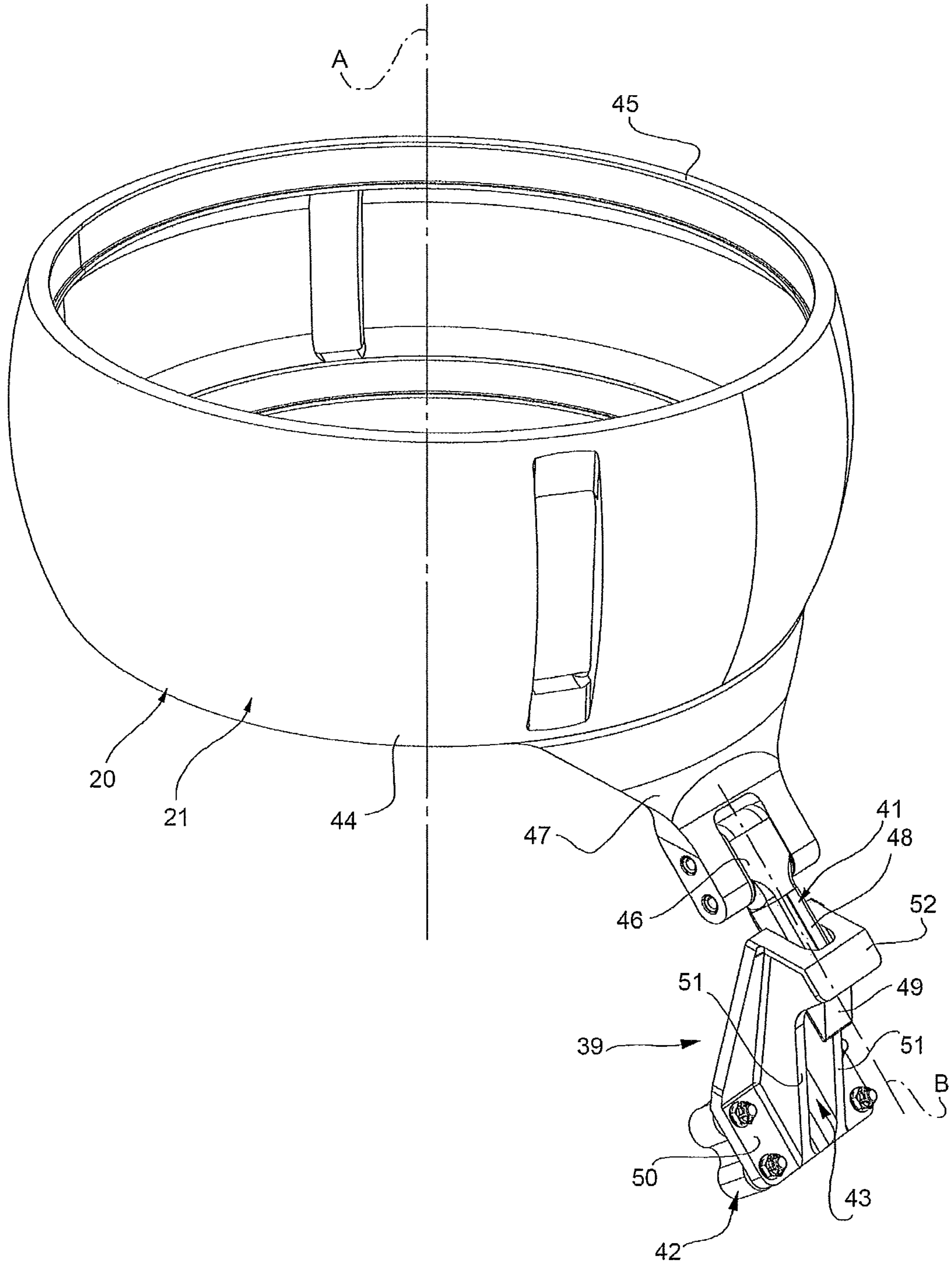

FIG. 5

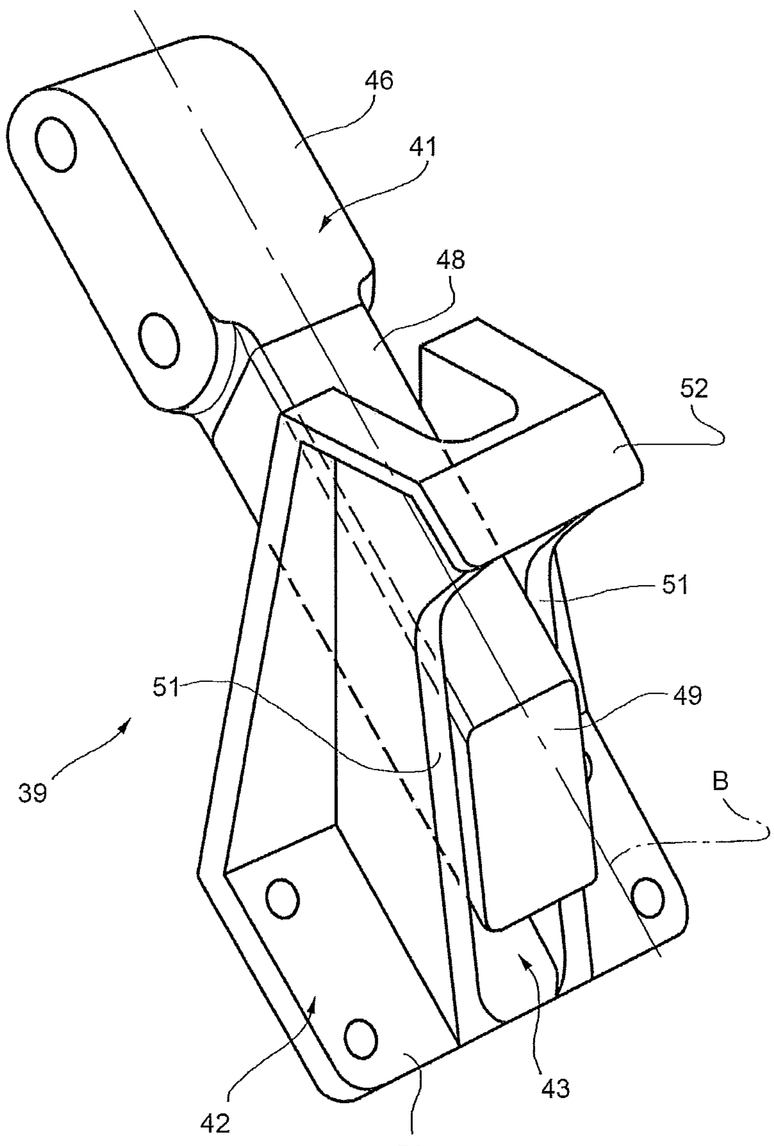

FIG. 6

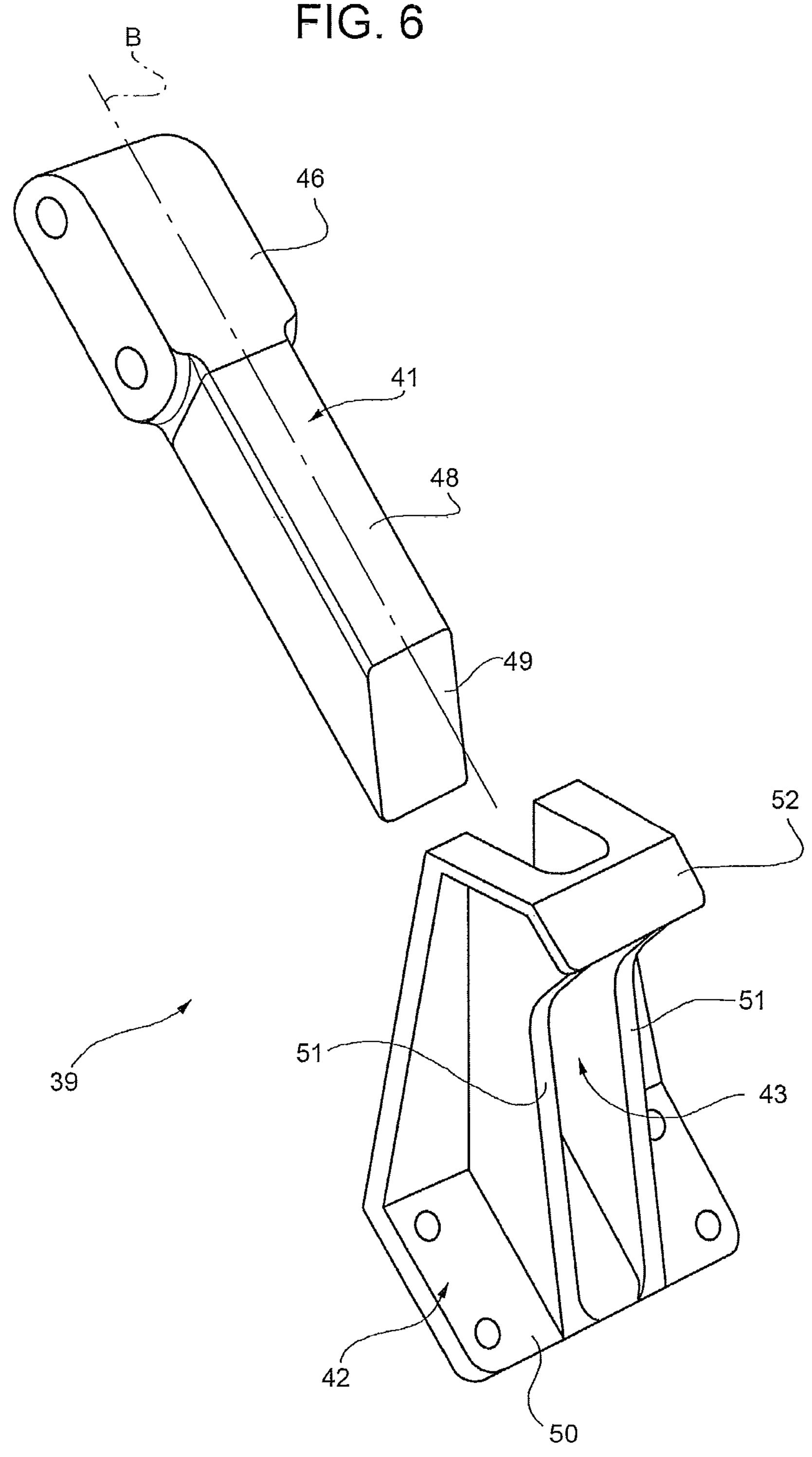

FIG. 7

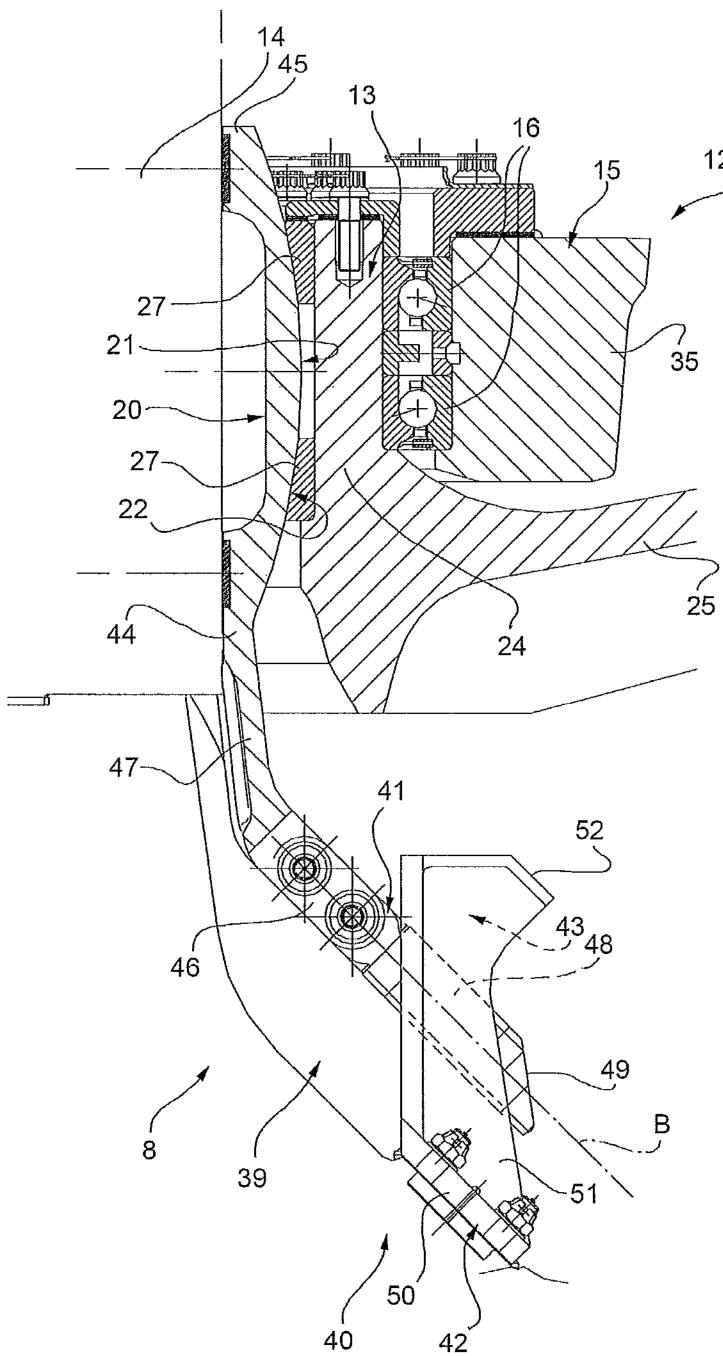
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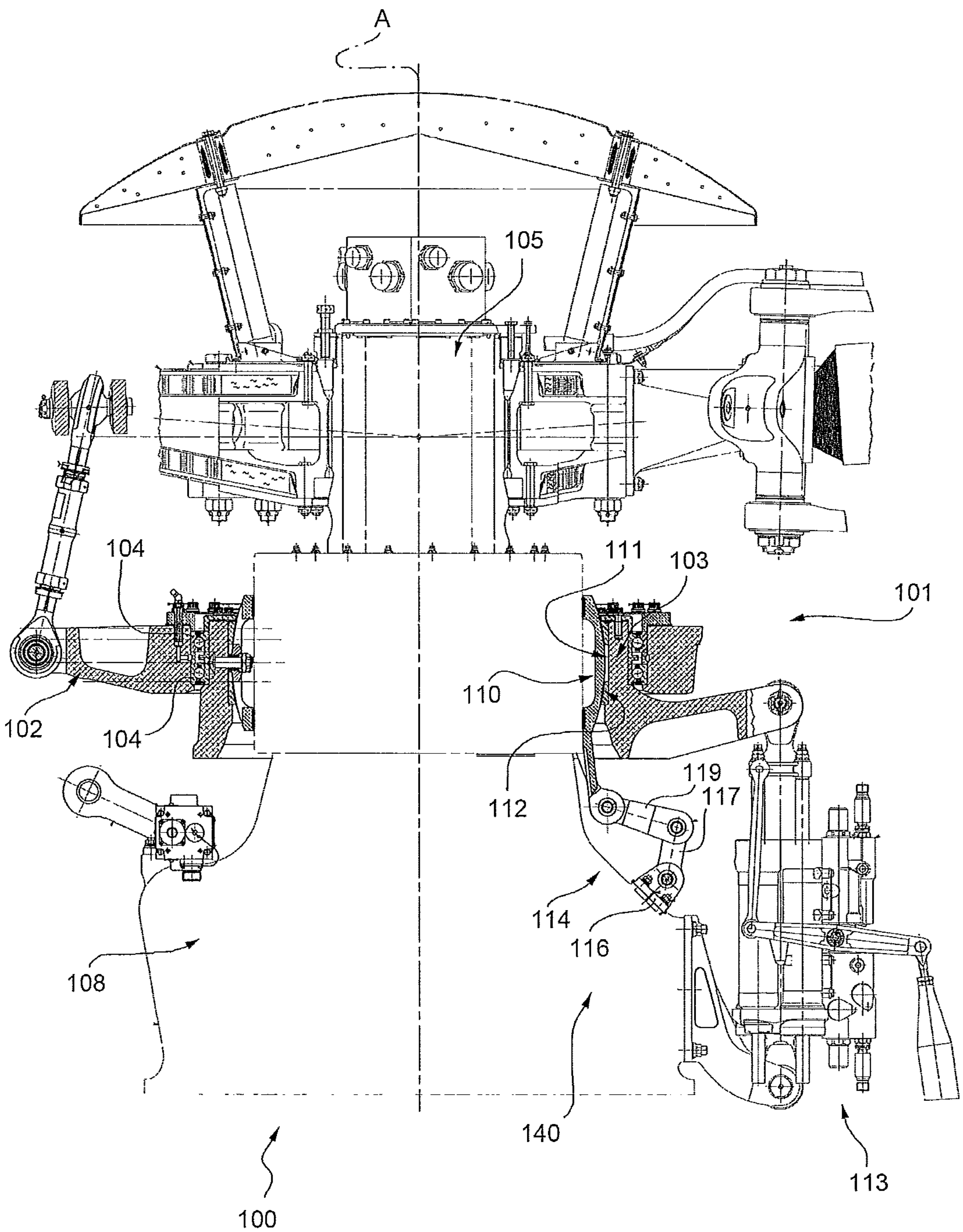
FIG. 8
PRIOR ART



ROTOR ASSEMBLY FOR AN AIRCRAFT CAPABLE OF HOVERING AND EQUIPPED WITH AN IMPROVED CONSTRAINT ASSEMBLY

The present invention relates to a rotor assembly for an aircraft capable of hovering, such as a helicopter or convertiplane, and equipped with an improved constraint assembly.

In the following description and attached drawings, reference is made, purely by way of a non-limiting example, to a helicopter rotor assembly.

FIG. **8** shows a section, with parts removed for clarity, of one example of a known helicopter rotor assembly, indicated as a whole by **100**.

BACKGROUND OF THE INVENTION

In known helicopter rotor assemblies, and particularly rotor assembly **100**, cyclic and collective pitch are normally controlled by an oscillating-plate control device **101** substantially comprising two concentric rings **102**, **103**. The outer ring **102**, i.e. the one radially outermost with respect to the central axis A, is supported for rotation, on bearings **104**, by the inner ring **103**, and is connected angularly to a drive shaft **105** to rotate a number of pitch-change rods **107**, each hinged eccentrically to a respective blade (not shown in FIG. **8**).

The inner ring **103** is fitted coaxially to a substantially sleeve-like movable member **110**, in turn mounted to slide axially on a fixed pylon **108**, through which the drive shaft **105** extends in axially-fixed, rotary manner.

Movable member **110** is bounded by a spherical annular outer surface **111**, which engages a spherical seat **112** on inner ring **103**; and inner ring **103** is normally locked angularly to spherical annular outer surface **111** of movable member **110** to oscillate in any direction with respect to movable member **110** about the centre of outer surface **111**.

Control device **101** also comprises a number of hydraulic actuators **113** equally spaced about and extending substantially parallel to drive shaft **105**, and which exert thrust on inner ring **103** to jointly move inner ring **103**, outer ring **102** and movable member **110** axially with respect to pylon **108**, and to oscillate rings **102** and **103** with respect to movable member **110** about axes substantially perpendicular to axis A of drive shaft **105**.

Movable member **110** is connected to pylon **108** by a compass-type connecting device **114** for preventing rotation of movable member **110** about axis A with respect to pylon **108**.

More specifically, connecting device **114** substantially comprises a bracket **116** projecting outwards from pylon **108**; a first connecting rod **117** hinged at one end to bracket **116**; and a second connecting rod **119** hinged at one end to movable member **110**, and at the other end to the end of connecting rod **117** opposite the end connected to bracket **116**.

Connecting device **114**, pylon **108**, and movable member **110** together define a constraint assembly **140** of helicopter rotor assembly **100**.

Other examples of known helicopter compass connecting devices are illustrated in EP-A-1031509 and FR 2,771,708.

Though functionally valid, compass connecting devices such as **114** are fairly complex (comprising three hinged parts), are relatively heavy and expensive, and call for constant lubrication and inspection, by being subjected in use to alternating loads which tend to increase slack between connecting rods **117** and **119**.

Moreover, to conform with aircraft design redundancy requirements, the number of such connecting devices must be doubled, thus further compounding the above drawbacks.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a rotor assembly for an aircraft capable of hovering, designed to eliminate the above drawbacks typically associated with known rotor assemblies and including a constraint assembly, which is cheap, reliable and lightweight, and employs fewer component parts than the known constraint assemblies described above.

According to the present invention, there is provided a rotor assembly, for an aircraft capable of hovering.

BRIEF DESCRIPTION OF THE DRAWINGS

A preferred, non-limiting embodiment of the present invention will be described by way of example with reference to the accompanying drawings, in which:

FIG. **1** shows a view in perspective of a helicopter in accordance with the teachings of the present invention;

FIG. **2** shows a larger-scale view in perspective of a rotor assembly and constraint assembly of the FIG. **1** helicopter;

FIG. **3** shows a larger-scale axial section, with parts removed for clarity, of the FIG. **2** rotor assembly and constraint assembly;

FIG. **4** shows a larger-scale view in perspective, with parts removed for clarity, of the constraint assembly according to the present invention;

FIG. **5** shows a larger-scale view in perspective of a detail of the FIG. **4** constraint assembly;

FIG. **6** shows an exploded view in perspective of the FIG. **5** detail;

FIG. **7** shows a larger-scale detail of the FIG. **3** section;

FIG. **8** shows the same axial section as in FIG. **3**, with parts removed for clarity, of a known helicopter rotor assembly and constraint assembly.

DETAILED DESCRIPTION OF THE INVENTION

Number **1** in FIG. **1** indicates as a whole an aircraft capable of hovering—in the example shown, a helicopter.

Helicopter **1** substantially comprises a fuselage **2**; a main rotor **3** mounted for rotation on the top of fuselage **2** to sustain helicopter **1** as a whole; and a tail rotor **4** fitted to the rear end of fuselage **2** and rotating in a plane crosswise to that of rotor **3** to counteract the torque generated on fuselage **2** by rotor **3**.

With reference to FIGS. **1**-**3**, rotor **3** substantially comprises a drive shaft **5** of axis A, and a number of blades **6** connected in known manner to the top end of drive shaft **5**, and projects from the top of a fixed housing or pylon **8** fitted in known manner (not shown) to fuselage **2**. More specifically, drive shaft **5** is supported inside housing **8** by means of bearings (not shown) to rotate about axis A, extends substantially vertically, and projects outwards through an end opening in housing **8**.

Rotor **3** and housing **8** together define a rotor assembly **10** in accordance with the teachings of the present invention.

Housing **8** is substantially bell-shaped, of axis A, and houses in known manner a motor reducer assembly (not shown) with an output member connected to the bottom end of drive shaft **5**.

With particular reference to FIGS. **2**, **3** and **7**, housing **8** is fitted on the outside with a cyclic and collective pitch control device connected in known manner to blades **6** of rotor **3** and indicated as a whole by **11**.

Device **11** substantially comprises an oscillating-plate assembly **12**, of axis A, in turn comprising a first annular member **13** fitted in angularly fixed manner about a substantially cylindrical top portion **14** of housing **8**, and a second annular member **15** fitted in rotary manner to annular member **13** with the interposition of two bearings **16**, and angularly integral with drive shaft **5** in known manner not shown.

Assembly **12** is fitted to a substantially sleeve-like movable member **20**, of axis A, mounted so as to be able to slide axially on top portion **14** of housing **8**. More specifically, movable member **20** is bounded externally by a spherical annular surface **21**—hereinafter referred to simply as 'spherical surface'—which engages a central spherical seat **22** on annular member **13** to allow assembly **12** to oscillate about axes perpendicular to axis A.

Device **11** also comprises a supporting and actuating assembly **23** (FIG. **3**) interposed between housing **8** and annular member **13**, and which cooperates with annular member **13** to move assembly **12**, together with movable member **20**, along axis A with respect to top portion **14** of housing **8**, and to oscillate assembly **12**, as stated, with respect to movable member **20** and portion **14**.

With particular reference to FIGS. **3** and **7**, annular member **13** comprises a main portion **24**, of axis A, from a bottom end portion of which extend radially outwards a number of arms **25** (only one shown) equally spaced angularly about axis A and terminating with respective fork-shaped end portions **26** for connection to supporting and actuating assembly **23**.

Main portion **24** of annular member **13** is fitted to spherical surface **21** of movable member **20** with the interposition of two rings **27**, of axis A, which are located on opposite sides of an intermediate plane of movable member **20** perpendicular to axis A and through the centre of spherical surface **21**, and the radially inner spherical annular surfaces of which define seat **22**. Respective layers of antifriction material, preferably Teflon, are interposed between rings **27** and spherical surface **21** of movable member **20**.

Annular member **13** is also secured in known manner to movable member **20** by two bolts **28**, which are located on diametrically opposite sides of axis A, are fitted through respective radial holes in main portion **24**, and each engage a respective key **30**, in turn engaging in sliding manner a respective substantially vertical slot **31** formed on the outside of movable member **20**. In this way, annular member **13** is locked angularly to spherical surface **21** of movable member **20**, and, by means of key **30** and slot **31**, can oscillate in any direction with respect to movable member **20** about the centre of spherical surface **21**.

Supporting and actuating assembly **23** comprises a number of hydraulic actuators **32** (only one shown partly), which have axes parallel to axis A, are equally spaced about axis A, and have respective output rods **33**, each connected at its top end to a fork-shaped end portion **26** of a respective arm **25** of annular member **13** by a ball joint **34**.

With reference to FIG. **3**, annular member **15** comprises a main portion **35** fitted radially outwards to main portion **24** of annular member **13** with the interposition of bearings **16**; and a number of arms **36** equal in number to blades **6** of rotor **3**, and which extend radially outwards from main portion **35**, and are each connected by a ball joint **37** to the bottom end of a respective pitch control rod **38**, the top end of which is connected eccentrically, in known manner not shown, to a respective blade **6** of rotor **3**.

With reference to FIGS. **2-7**, movable member **20** is connected to housing by a connecting device **39** for preventing rotation of movable member **20** about axis A and with respect to housing **8**.

Connecting device **39**, housing **8**, and movable member **20** define a constraint assembly **40** of rotor assembly **10** of helicopter **1**.

An important feature of the present invention is that connecting device **39** comprises a retaining arm **41** projecting outwards from movable member **20** and extending at a distance of other than zero from axis A; and an antirotation bracket **42**, which projects from housing **8**, also extends at a distance of other than zero from axis A, and defines a through opening **43** engaged in sliding manner by retaining arm **41**.

With particular reference to FIGS. **4-7**, retaining arm **41** fully extends in a longitudinal direction B sloping with respect to axis A, and slides inside opening **43** in antirotation bracket **42** in a movement parallel to axis A.

As shown clearly in FIGS. **4** and **5**, direction B allows retaining arm **41** to engage and disengage opening **43** in antirotation bracket **42**.

More specifically, retaining arm **41** extends from an axial end **44** of movable member **20**, located closer to fuselage **2** of helicopter **1** than the other axial end **45** facing blades **6**.

More specifically, retaining arm **41** is located in a predetermined angular position about axis A, and is fixed rigidly at one end **46** to an appendage **47** projecting from the bottom of axial end **44** of movable member **20**.

Retaining arm **41** has a parallelepiped-shaped main body **48** elongated in direction B, and terminates with a free end **49** tapered on one side.

Antirotation bracket **42** substantially comprises a base portion **50** fixed to the outer surface of a flared portion of housing **8**; and two walls **51** projecting, parallel to each other and to axis A, from base portion **50**, and connected to each other, on the opposite side to base portion **50**, by a connecting portion **52**.

Base portion **50**, walls **51**, and connecting portion thus define a through opening **43** with a prismatic profile.

As shown clearly in FIGS. **4**, **5** and **7**, retaining arm **41** engages opening **43** in antirotation bracket **42** loosely in a direction parallel to walls **51** and axis A, so as to slide between walls **51** in a movement parallel to axis A.

Preferably, retaining arm **41** is covered with antifriction material, and the lateral edge of opening in antirotation bracket **42** is surface treated to resist wear.

The way in which rods **33** of actuators **32**, oscillating-plate assembly **12**, movable member **20**, and rods **38** adjust the cyclic and collective pitch of blades of rotor **3** is known and therefore needs no further explanation here.

Needless to say, the so-called 'external control' device **11** described, i.e. located outside housing **8** and drive shaft **5**, may easily be replaced, by anyone skilled in the art, with a known so-called 'internal control' cyclic and collective pitch control device (not shown), in which assembly **12** and movable member **20** are mounted to slide on a fixed support inside drive shaft **5**.

The advantages of rotor assembly **10** and constraint assembly **40** according to the present invention will be clear from the above description.

In particular, connecting device **39**, by comprising only two component parts of simple design (retaining arm **41** and antirotation bracket **42**), is much lighter and cheaper than known connecting devices.

The solution according to the present invention involves no hinges, and is much more precise than known compass-type connecting devices, i.e. is a sliding solution with very little slack, which remains unchanged even after many years' service.

Clearly, changes may be made to rotor assembly **10** and constraint assembly **40** as described and illustrated herein without, however, departing from the protective scope of the accompanying Claims.

In particular, rotor assembly **10** and constraint assembly **40** may also be employed to advantage on convertiplanes.

Moreover, constraint assembly **40** may also be used on aircraft landing gears.

The invention claimed is:

1. A rotor assembly (**10**) for an aircraft (**1**) capable of hovering, said rotor assembly (**10**) having an axis (A) and comprising:

a supporting member (**8**) coaxial with said axis (A);

a drive shaft (**5**) extending coaxially through said supporting member (**8**) and fitted to the supporting member (**8**) in an axially fixed position and so as to rotate about said axis (A);

a movable member (**20**) mounted so as to be able to translate along and rotate about said axis (A);

an oscillating-plate assembly (**12**), which is coaxial with said axis (A), is fitted to said movable member (**20**) to oscillate with respect to it about transverse axes substantially perpendicular to said axis (A), and in turn comprises a first annular member (**13**) angularly fixed to said movable member (**20**), and a second annular member (**15**) which rotates on said first annular member (**13**) together with said drive shaft (**5**);

supporting and actuating means (**23**), which cooperate with said first annular member (**13**) to move said oscillating-plate assembly (**12**) and said movable member (**20**) jointly along said axis (A) with respect to said supporting member (**8**), and to oscillate said oscillating-plate assembly (**12**) about said transverse axes with respect to said movable member (**20**); and

connecting means (**39**) for connecting said supporting member (**8**) and said movable member (**20**), to prevent rotation of said movable member (**20**) about said axis (A) with respect to said supporting member (**8**);

characterized in that said connecting means (**39**) comprise:

a retaining arm (**41**) projecting outwards from one (**20**) of said supporting member (**8**) and said movable member (**20**), and extending at a distance of other than zero from said axis (a); and

an antirotation bracket (**42**), which projects from the other (**8**) of said supporting member (**8**) and said movable member (**20**), extends at a distance of other than zero from said axis (A), and defines a through opening (**43**) engaged in sliding manner by said retaining arm (**41**).

2. A rotor assembly as claimed in claim **1**, wherein said retaining arm (**41**) fully extends in a longitudinal direction (B) sloping with respect to said axis (A), and slides inside said opening (**43**) in said antirotation bracket (**42**) in a movement parallel to said axis (A).

3. A rotor assembly as claimed in claim **2**, wherein said longitudinal direction (B) allows said retaining arm (**41**) to engage and disengage said opening (**43**) in said antirotation bracket (**42**).

4. A rotor assembly as claimed in claim **2**, wherein said retaining arm (**41**) engages said opening (**43**) in said antirotation bracket loosely in a direction parallel to said axis (A).

5. A rotor assembly as claimed in claim **1**, wherein said opening (**43**) has a prismatic profile.

6. A rotor assembly as claimed in claim **1**, wherein said antirotation bracket (**42**) is fixed to said supporting member (**8**); and said retaining arm (**41**) is fixed to said movable member (**20**).

7. A rotor assembly as claimed in claim **6**, wherein said retaining arm (**41**) is fixed rigidly to said movable member (**20**).

8. A rotor assembly as claimed in claim **1**, wherein said retaining arm (**41**) is covered with antifriction material.

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